Melting Temperature and High-Temperature Emissivity of Rare-Earth Silicates

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In recent years, rare-earth silicates have become the industry standard for coating state-of-the-art silicon carbide ceramic matrix composites for gas turbine engine components, due to their low volatility, high melting point, and thermal shock resistance. Current research looks to design rare-earth silicate based thermal and environmental barrier coatings (T/EBCs) with improved resistance to steam, CMAS (CaO-MgO-Al_2O_3-SiO_2), and thermal stresses, while maintaining high temperature performance and stability. In this work we study the high temperature limits of a variety of single and multiple principle component rare-earth mono- and disilicates and rare earth apatites. A laser heating and radiation pyrometry based technique is employed to measure the melting point and high temperature emissivity of these materials systems. In this approach, a high-power IR laser is used to heat the sample just beyond its melting point while both a 256-channel spectropyrometer and a single-wavelength pyrometer with high temporal resolution monitor the radiative temperature of the sample surface in the center of the heated region. While the sample surface is locally molten, the laser is shuttered and the melting point is captured through the observed thermal arrest in the temperature response during cooling. To ascertain the real melting temperature from the measured radiative temperature, we utilize the spectrally resolved pyrometer response to calculate the gray emissivity in the visible, and apply this to the fast, single-wavelength pyrometer measurement. We find our results agree with trends observed in previous literature. To further study thermal transport in the rare-earth silicates, we also measure room temperature thermal conductivity by time-domain thermoreflectance (TDTR). The thermal conductivity, melting point and emissivity measurements are used to evaluate each material's feasibility as a T/EBC in a high temperature gas turbine environment.